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(54) A METHOD OF TREATING HUMAN AND ANIMAL WASTE PRODUCTS AND PRODUCTS SO OBTAINED

(71) We, AN FORAS TALUNTAIS, a Statutory Body Corporate existing under the Agriculture (An Foras Taluntais) Act 1958, of 19, Sandymount Avenue, Dublin 4, Republic of Ireland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method of treating human, animal or food processing waste products such as human excreta, pig, poultry, cattle or sheep manure, dairy effluent, blood, and intestinal contents, and to products obtained by the method.

Most aquatic and marine systems have a very low primary productivity because of limitations imposed by the low levels of major nutrients such as nitrogen, phosphorous, iron, carbon or silica. The addition of these elements, in suitable form, to such systems leads to great increases in primary production, usually by planktonic algae or blooms which are often the first spectacular signs of excess nutrients and eutrophication in fresh-water lakes. After death, the decomposition of these vast quantities of algae may rapidly and completely exhaust the oxygen supply of the water, leading to anaerobic conditions, and hence the virtual elimination of the normal fauna.

Generally (although not in every case) pollution control has only been instituted when damage to public health or to natural ecosystems has become widespread and obvious. It is clear, however, that many pollutants can have subtle and little understood effects on ecosystems and, even more disturbing, our ability to predict long-term effects does not seem to be particularly sophisticated.

With the recent development of intensive animal production units a problem of pollution by animal wastes has become evident. This is particularly true in relation to large pig production units which in many instances do not include land upon which such animal manure could be spread. The proximity of these units to streams, rivers and lakes leads in many cases to gross pollution thus affecting adversely the quality of life in general. Pollution from these and other sources has had a detrimental effect on both the bacterial and fish life of a number of important rivers and lakes causing a serious amenity problem. In addition, pig manure in particular, has a most unpleasant odour, and the presence of faecal bacteria such as *E-coli* organisms give rise to a health hazard. A safe, efficient and economic method of disposing of such manures is necessary, but such disposal is made difficult by the fact that the manure is generally in the form of a slurry and is difficult to handle. The present methods of disposing of manure include (a) storage and spreading on land; and (b) storage, drying and aerobic oxidation followed by land spreading. Each of these methods has a number of limitations, including unavailability of land on which to spread the manure, the inability of the land to absorb nutrients from manure due to poor soil permeability and/or high rainfall, possible deleterious effects on grass species and toxicity to animals caused by herbage accumulation of minerals such as copper. Furthermore, the cost of spreading may be quite high relative to the fertilizing efficiency of the manure which can be lowered by fermentation losses and loss of ammonia nitrogen.

One way of overcoming the problem is to treat manure so that the phosphorus and much of the nitrogen are removed from the manure effluent before it is released into river and lake systems. Phosphorus can be removed chemically but this is not an ideal solution since valuable plant nutrients are lost, particularly if a tertiary sludge digestion treatment is used to get rid of the remaining solid wastes. Another recommended method is to convert the solid wastes into dried fertilizer and to recycle it through the agricultural system, thus reducing the demand for expensive and highly leachable artificial fertilizers.

It is an object of the present invention to provide a method of treating waste in slurry form so as to render it in a form in which it is more easily handled and in which it is substantially sterile and odourless, and to protect its nutrients from rapid degradation.

Accordingly, the invention provides a method of treating human and animal waste products in the form of a slurry to produce a semi-solid material which comprises adding to the slurry and adximing therewith an aldehyde together with a nitrogenous substance having free amine or amide groupings and capable of complexing with the aldehyde, and then adjusting the pH of the mixture until it is less than 4 to promote complex formation. The resultant mass is intimately mixed and allowed to stand for a period to permit complex formation. The degree of aggregation of the final product is dependant on the amount of agitation to which it is subjected during the above period. The pH of the material is then adjusted to the neutral range by the addition of a suitable alkali.

Preferably, the aldehyde is formaldehyde, acetaldehyde or glutaraldehyde. The preferred nitrogenous substance is urea or a derivative thereof such as biuret and thiourea and any mixture of these substances. Nitrogenous substances may also comprise the following: casein, gelatin, animal hides, hoofs, crushed bones, blood, animal offals, feathers and wool. Where urea or any other nitrogenous substances are used they should be added to the slurry in an amount comprising from 1 to 100% by weight of the slurry. The molar weight ratio in the case of pure chemicals e.g. nitrogenous to aldehyde ratio should be equal to or greater than 1.0. In the case of pure chemicals and of other nitrogenous substances the amount of aldehyde added should not exceed the complexing potential of the reactants thus avoiding excess aldehyde in the final product.

In a preferred method according to the invention the formaldehyde (conc. 0.12 to 40%) is first added to the slurry and admixed therewith so as to complex any nitrogen present in the slurry. The urea is then added, dissolved and the pH of the mixture is adjusted to the range 2 to 3 by adding a suitable inorganic acid such as sulphuric acid. The particular acid selected may vary depending upon the buffer capacity of the slurry material and the final composition required. The admixture is then agitated to intimately mix the components, and is allowed to stand to permit complex formation. The method is carried out at ambient temperature but if desired the temperature of the admixture may be raised up to 120°C in which case the standing time can be reduced considerably. At the end of this period the pH of the material is again adjusted preferably to, or slightly below, the neutral range by the addition of a suitable alkali such as calcium carbonate, calcium oxide, calcium hydroxide or magnesium carbonate. Excess alkali may be added to the mixture if this is desired for specific purposes.

Although in the preferred embodiment described above the formaldehyde is first added to the slurry, this sequence may be reversed and the urea may be added first, or indeed at the same time as the formaldehyde.

The material obtained by the method of the invention is an excellent controlled release fertilizer which is easily handled and is sterile and odourless. It is thus suitable for use as a general agricultural and horticultural fertilizer. The supernatant liquid after sedimentation may be decanted, centrifuged, evaporated or peat moss may be added to provide a compost-like material. The fertilizer may be supplemented by the addition of phosphorus, sulphur, potassium and appropriate trace elements. If necessary the nitrogen content of the material may be increased by the addition of further urea or other sources of nitrogen. The trace elements may be used in a fritted form or sequestered form or as salts of the elements zinc, boron, iron, manganese and molybdenum. Other additives such as sequestering agent (EDTA), hormones, herbicides, pesticides and sand may be included. Alternatively, the fertilizer of the invention may be blended with standard chemical fertilizers to provide composts for potting and seeding growth or fertilizer compositions for general use in domestic gardens, golf courses, horticulture and agriculture.

The following example is intended to illustrate the invention:

EXAMPLE

11.3 kg of formaldehyde (conc. 37%) was added to and mixed with 45 kg of pig manure which was of low dry matter content and in slurry form. 9 kg of urea was then dissolved in the slurry. The pH of the admixture was adjusted to 2.5 by the addition of approximately 0.45 kg of sulphuric acid. The admixture was then agitated to intimately mix the constituents and the mixture was allowed to stand overnight. After that period it was found that the mixture was of a semi-solid consistency somewhat like wet sea sand. Approximately 0.45 kg of calcium carbonate was then added to the semi-moist material to bring the pH thereof into the neutral range, and the material was then mixed with 8 kg of peat moss.

On analysis the material was found to have a dry matter content of 32.2% and was of the following composition:

Total Ash	:	2.7% of wet matter
N	:	6.4% of wet matter
P	:	0.1% of dry matter
K	:	0.18% of dry matter
Cu	:	30 parts per million
Mn	:	8 parts per million
Zn	:	50 parts per million
Fe	:	0.11% of dry matter
Ca	:	3.0% of dry matter
Mg	:	0.11% of dry matter
Na	:	0.14% of dry matter

The products of the invention have the advantage that the major nitrogen content of the material is in a complexed form and is released slowly to provide all year round availability. Leaching of valuable nutrients is rendered minimal because of the complexing and absorption which takes place in the process and this is particularly important in the case of slurry nutrients which are extremely soluble and as a consequence easily lost. Possible harmful effects to the ecosystem due to the presence of dangerous bacteria or helminth parasites are eliminated because of the presence of formaldehyde. Substances normally present in manures which produce noxious odours are so affected by the process as to provide a substantially odourless material which, in addition, is friable, easily handled, stored and packaged.

WHAT WE CLAIM IS:—

1. A method of treating human and animal waste products in the form of a slurry to produce a semi-solid material comprising adding to the slurry and admixing therewith an aldehyde together with a nitrogenous substance having free amine or amide groupings and capable of complexing with the aldehyde, then adjusting the pH of the mixture until it is less than 4 to promote complex formation, and subsequently neutralizing the material.

2. A method as claimed in claim 1, wherein after the initial adjustment of the pH of the mixture, the mixture is agitated and allowed to stand until complex formation is completed whereupon the pH of the material is adjusted to the neutral range by addition of an alkaline substance.

3. A method as claimed in any of the preceding claims, wherein the aldehyde is formaldehyde, acetaldehyde or glutaraldehyde.

4. A method as claimed in any of the preceding claims, wherein the nitrogenous substance is urea, or a derivative thereof.

5. A method as claimed in claim 4, wherein the nitrogenous substance is biuret or thiourea, or a mixture thereof.

6. A method as claimed in any of claims 1 to 3, wherein the nitrogenous substance comprises casein, gelatin, animal hides, hoofs, crushed bone, blood, animal offals, feathers or wool.

7. A method as claimed in any one of the preceding claims, wherein the nitrogenous substance is added to the slurry in an amount comprising from 1 to 100% by weight of the slurry.

8. A method as claimed in claim 1, wherein formaldehyde is added to the slurry and admixed therewith so as to complex any nitrogen present in the slurry, urea or a derivative thereof is then added to the mixture, dissolved, and the pH of the mixture is adjusted to the range 2 to 3 by the addition of a suitable inorganic acid, the admixture is then agitated to intimately mix the components, and is allowed to stand to permit complex formation.

9. A method as claimed in any of the preceding claims, wherein the waste products comprise animal manure, human excreta, dairy effluent, blood or intestinal contents.

10. A method of treating waste products substantially as hereinbefore described with reference to the example.

11. A fertilizer material whenever produced by the method claimed in any one of claims 1 to 10.

12. A fertilizer material as claimed in claim 11 admixed with peat moss.

13. A fertilizer material as claimed in claim 11 or 12 containing phosphorus, sulphur, potassium and appropriate trace elements.

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